AHRI Standard 520
(formerly ARI Standard 520)

2004 Standard for

PERFORMANCE RATING OF POSITIVE DISPLACEMENT CONDENSING UNITS

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IMPORTANT

SAFETY RECOMMENDATIONS

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Note:

This standard supersedes ARI Standard 520-97.

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PERFORMANCE RATING OF POSITIVE DISPLACEMENT CONDENSING UNITS

Section 1. Purpose

1.1 *Purpose*. The purpose of this standard is to establish, for positive displacement condensing units: definitions; test requirements; rating requirements; minimum data requirements for Published Ratings; operating requirements; marking and nameplate data and conformance conditions.

1.1.1 *Intent*. This standard is intended for the guidance of the industry, including manufacturers, designers, installers, contractors and users.

1.1.2 *Review and Amendment*. This standard is subject to review and amendment as technology advances.

Section 2. Scope

2.1 *Scope*. This standard applies to electric motor driven, single and variable capacity positive displacement condensing units for air-cooled, evaporatively-cooled, and water-cooled refrigeration applications.

2.1.1 *Refrigerant*. The rating points in this standard are based on commonly used refrigerants.

2.2 *Exclusions*.

2.2.1 This standard does not apply to condensing units intended for use in:

a. Household refrigerators and freezers
b. Automotive air-conditioners
c. Dehumidifiers

Section 3. Definitions

All terms in this document follow the standard industry definitions in the current edition of *ASHRAE Terminology of Heating, Ventilation, Air Conditioning and Refrigeration* unless otherwise defined in this section.

3.1 *Coefficient of Performance (COP).* A ratio of the Cooling/Heating Capacity in watts [W] to the power input values in watts [W] at any given set of Rating Conditions expressed in watts/watt [W/W]. For heating *COP,* supplementary resistance heat shall be excluded.

3.1.1 *Standard Coefficient of Performance.* A ratio of the capacity to power input value obtained at Standard Rating Conditions.

3.2 *Energy Efficiency Ratio, (EER)*. A ratio of the Cooling Capacity in Btu/h to the power input values in watts at any given set of Rating Conditions expressed in Btu/(W ·h).

3.2.1 *Standard Energy Efficiency Ratio*. A ratio of the capacity to power input value obtained at Standard Rating Conditions.

3.3 *Positive Displacement Condensing Unit*. A specific combination of refrigeration system components for a given refrigerant, consisting of one or more electric motor driven positive displacement compressors, condensers, and accessories as provided by the manufacturer.

3.4 *Published Rating.* A statement of the assigned values of those performance characteristics, under stated rating conditions, by which a unit may be chosen to fit its application. These values apply to all units of like nominal size and type (identification) produced by the same manufacturer. The term Published Rating includes the rating of all performance characteristics shown on the unit or published in specifications, advertising or other literature controlled by the manufacturer, at stated Rating Conditions.

3.4.1 *Application Rating*. A rating based on tests performed at application Rating Conditions, (other than Standard Rating Conditions).

3.4.2 *Standard Rating*. A rating based on tests performed at Standard Rating Conditions.

3.5 *Rating Conditions.* Any set of operating conditions under which a single level of performance results and which causes only that level of performance to occur.

3.5.1 *Standard Ratings Conditions.* Rating conditions used as the basis of comparison for performance characteristics.

3.6 *Refrigerating Capacity*. The capacity associated with the increase in total enthalpy between the liquid refrigerant entering the expansion valve and superheated return gas multiplied by the mass flow rate of the refrigerant.

3.7 *"Shall" or "Should". "*Shall" or "should" shall be interpreted as follows:

3.7.1 *Shall*. Where "shall" or "shall not" is used for a provision specified, that provision is mandatory if compliance with the standard is claimed.

Should. "Should," is used to indicate provisions which are not mandatory, but which are desirable as good practice.

Section 4. Test Requirements

4.1 *Test Requirements*. All Published Ratings shall be verified by tests conducted in accordance with ASHRAE Standard 23.

Section 5. Rating Requirements

5.1 *Standard Ratings.* Standard Ratings shall be established at the Standard Rating Conditions in Table 1 and shall include its associated power input and Energy Efficiency Ratio (EER). When tested with a specified motor, the associated compressor speed (external drive compressors only) shall also be included as part of the rating. The power required to operate all included accessories such as condenser fans, water pumps, controls, and similar accessories shall be accounted for in the power input and Energy Efficiency Ratio. When external accessories such as water pumps, remote fans, and similar accessories are required for the operation of the unit but not included with the unit, the manufacturer shall clearly state that the rated power input and Energy Efficiency Ratio do not account for additional power required by these external accessories. If a water-cooled condenser is used, the cooling water flow rate and pressure drop shall be specified as part of the rating.

5.2 *Application Ratings*. Application Ratings shall consist of a Capacity Rating plus the associated power input and Energy Efficiency Ratio (EER). When tested with a specified motor, the associated compressor speed (external drive compressors only), shall also be included as part of the rating. The power required to operate all included accessories such as condenser fans, water pumps, controls, and similar accessories shall be accounted for in the power input and Energy Efficiency Ratio.

When external accessories such as water pumps, remote fans, and similar accessories are required for the operation of the unit but are not included with the unit, the manufacturer shall clearly state that the rated power input and Energy Efficiency Ratio do not account for additional power required by these external accessories.

If a water-cooled condenser is used, the cooling water flow rate and pressure drop shall be specified as part of the rating.

All of the above data shall be reported at stated conditions other than those presented in Table 1. Application Ratings shall be reported at rated voltage, phase, and frequency.

5.3 *Tolerances*. To comply with this standard, measured test results shall not be less than 95% of Published Ratings for capacity and energy efficiency and power input shall be no more than 105% of the rated values.

Section 6. Minimum Data Requirements for Published Ratings

6.1 *Minimum Data Requirements for Published Ratings.* As a minimum, Published Ratings shall include all Standard Ratings. All claims to ratings within the scope of this standard shall include the statement "Rated in accordance with ARI Standard 520". All claims to ratings outside the scope of this standard shall include the statement "Outside the scope of ARI Standard 520". Wherever Application Ratings are published or printed, they shall include a statement of the conditions at which the ratings apply.

Section 7. Operating Requirements

7.1 *Maximum Loading Conditions*. The maximum suction dew point temperature limit shall be published. This limit shall be established with the condensing unit operating at conditions as described below:

a. Ambient temperature surrounding the condensing unit of 115°F [46.1°C] dry-bulb for all types, 115°F [46.1°C] dry-bulb air temperature entering condenser on air-cooled condensing units, and 80°F [27°C] wet-bulb for evaporatively-cooled condensing units.
b. Water inlet temperature of 90°F [32°C] and water outlet temperature of 105°F [40.6°C] for water-cooled condensing units. Make-up water temperature of 90°F [32°C] for evaporatively-cooled units.

7.2 *Loading Requirements*. The condensing unit shall be capable of operating continuously at the stated maximum loading conditions of 7.1 for a minimum period of two hours at minimum and maximum utilization voltages as described in ARI Standard 110, Table 1.

Section 8. Marking and Nameplate Data

8.1 *Condensing Unit Nameplate Marking*. As a minimum, each condensing unit shall have a nameplate, affixed to its housing or base, on which at least the following information shall be marked:

a. Manufacturer's name and/or symbol
b. Model number
c. Refrigerant designation per ASHRAE 34
d. Input voltage and frequency (Hz)
e. Rated load current (where applicable)

Nameplate voltages for 60 Hertz systems shall include one or more of the equipment nameplate voltage ratings shown in Table 1 of ARI Standard 110. Nameplate voltages for 50 Hertz systems shall include one or more of the utilization voltages shown in Table 1 of IEC Standard 60038.

Section 9. Conformance Conditions

9.1 *Conformance*. While conformance with this standard is voluntary, conformance shall not be claimed or implied for products or equipment within the standard's *Purpose* (Section 1) and *Scope* (Section 2) unless such product claims meet all of the requirements of the standard and all of the testing and rating requirements are measured and reported in complete compliance with the standard. Any product that has not met all the requirements of the standard shall not reference, state, or acknowledge the standard in any written, oral, or electronic communication.

Table 1. AHRI Standard Rating Conditions for Condensing Units for Refrigeration Applications*

Suction Dew Point Temperature		Com-pressor Type	Return Gas Temperature		Type of Condensing Unit								
					Air-Cooled		Water-Cooled				Evaporatively - Cooled		
					Air Entering Dry-Bulb (indoor/outdoor)		In		Out		Air Entering Wet-Bulb Temperature		Variable Capacity Setting***
°F	°C		°F	°C	°F	°C	°F	°C	°F	°C	°F	°C	
45	7.2	All	65	18	90/95	32/35	85	29	95	35	75	24	MAX/MIN
20	-6.7	All**	40/ 65**	4.4/ 18**	90/95	32/35	85	29	95	35	75	24	MAX/MIN
-10	-23	Hermetic	40	4.4	90/95	32/35	85	29	95	35	75	24	MAX/MIN
-25	-32	All**	40/ 65**	4.4/ 18**	90/95	32/35	85	29	95	35	75	24	MAX/MIN
-40	-40	All**	40/ 65**	4.4/ 18**	90/95	32/35	85	29	95	35	75	24	MAX/MIN

* Sub-cooling in °F [°C], shall be stated as obtained under pertinent application conditions, as measured at the liquid line leaving the condensing unit.

** 1) For hermetic type compressors, 40°F [4.4°C] return gas temperature shall be used.

2) For external drive and accessible hermetic type compressors, 65°F [18°C] return gas temperature shall be used.

*** The maximum and minimum capacity setting is the highest and lowest displacement capacity by the condensing unit.

APPENDIX A. REFERENCES – NORMATIVE

A1 Listed here are all standards, handbooks and other publications essential to the formation and implementation of the standards. All references in this appendix are considered as part of the standard.

A1.1 ANSI/ASHRAE Standard 34-2001 with Addenda, *Number Designation and Safety Classification of Refrigerants,* 2001, American National Standards Institute/American Society of Heating, Refrigerating and Air-Conditioning Engineers, 11 West 42nd Street, New York, NY 10036, U.S.A./1791 Tullie Circle N.E., Atlanta, GA 30329, U.S.A.

A1.2 AHRI Standard 110-2002 (formerly ARI Standard 110-2002), *Air-Conditioning and Refrigerating Equipment Nameplate Voltages*, 2002, Air-Conditioning, Heating, and Refrigeration Institute, 2111 Wilson Boulevard, Suite 500, Arlington, VA 22201, U.S.A.

A.1.3 ASHRAE Standard 23-1993, *Methods of Testing for Rating Positive Displacement Refrigerant Compressors and Condensing Units*, 1993, American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., 1791 Tullie Circle, N.E., Atlanta, GA 30329-5478, U.S.A.

A1.4 *ASHRAE Terminology of Heating, Ventilation, Air Conditioning and Refrigeration*, Second Edition, 1991, American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., 1791 Tullie Circle, N.E., Atlanta, GA 30329-5478, U.S.A.

A1.5 IEC Standard 60038, *IEC Standard Voltages*, 2002, International Electrotechnical Commission, 3, rue de Varembe, P.O. Box 131, 1211 Geneva 20, Switzerland.

A1.6 ISO 917: 1989, *Testing of Refrigerant Compressors,* 1989, International Organization for Standardization, Case Postale 56, CH-1211, Geneva 21 Switzerland.

APPENDIX B. REFERENCES – INFORMATIVE

None.

APPENDIX C. METHOD TO HANDLE ZEOTROPIC MIXTURES – INFORMATIVE

C1 Cycle Process

For reference, Figure C1 shows a typical single stage cycle for single component refrigerants and azeotropic mixtures. The description is consistent with the ISO 917 standard. As shown, the evaporating and condensing processes occur at fixed temperatures t_o and t_c.

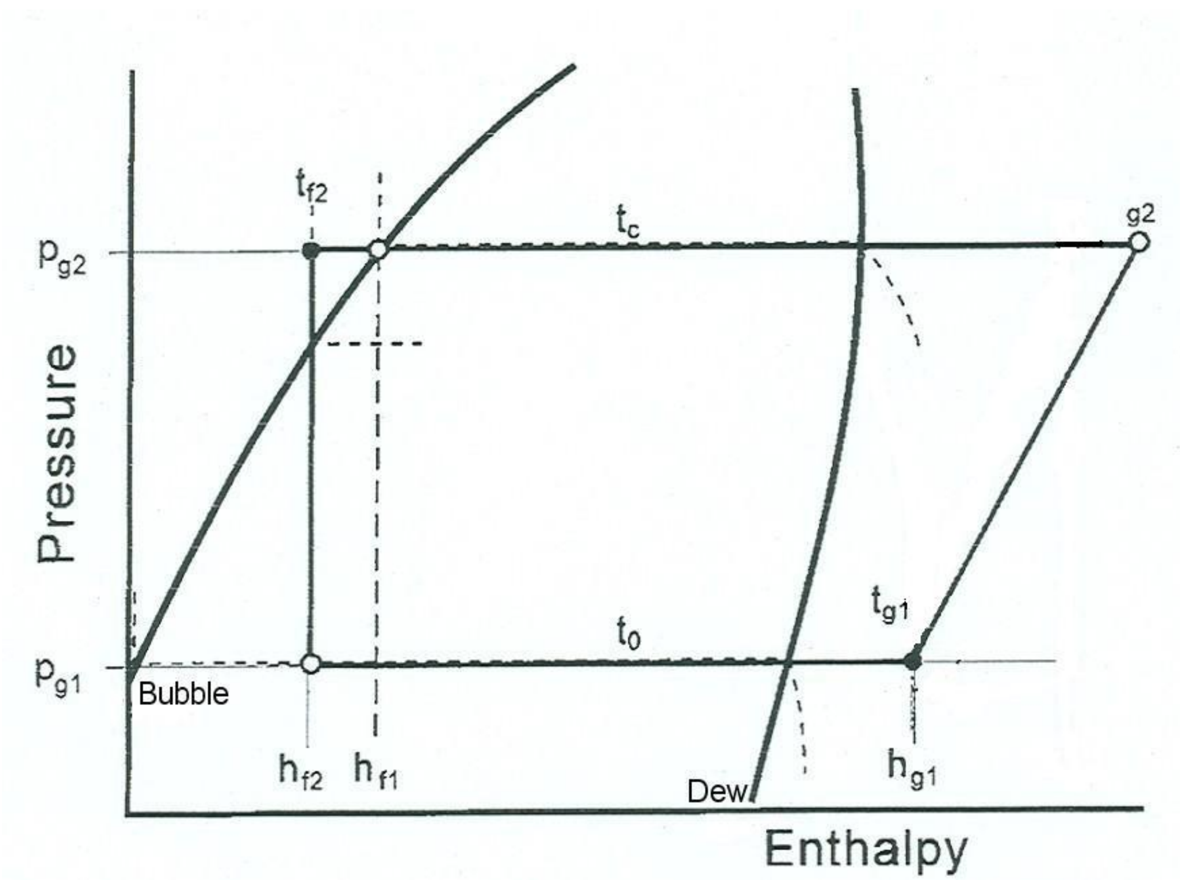

Figure C1: Cycle Process for Single Component Refrigerants and Azeotropic Mixtures

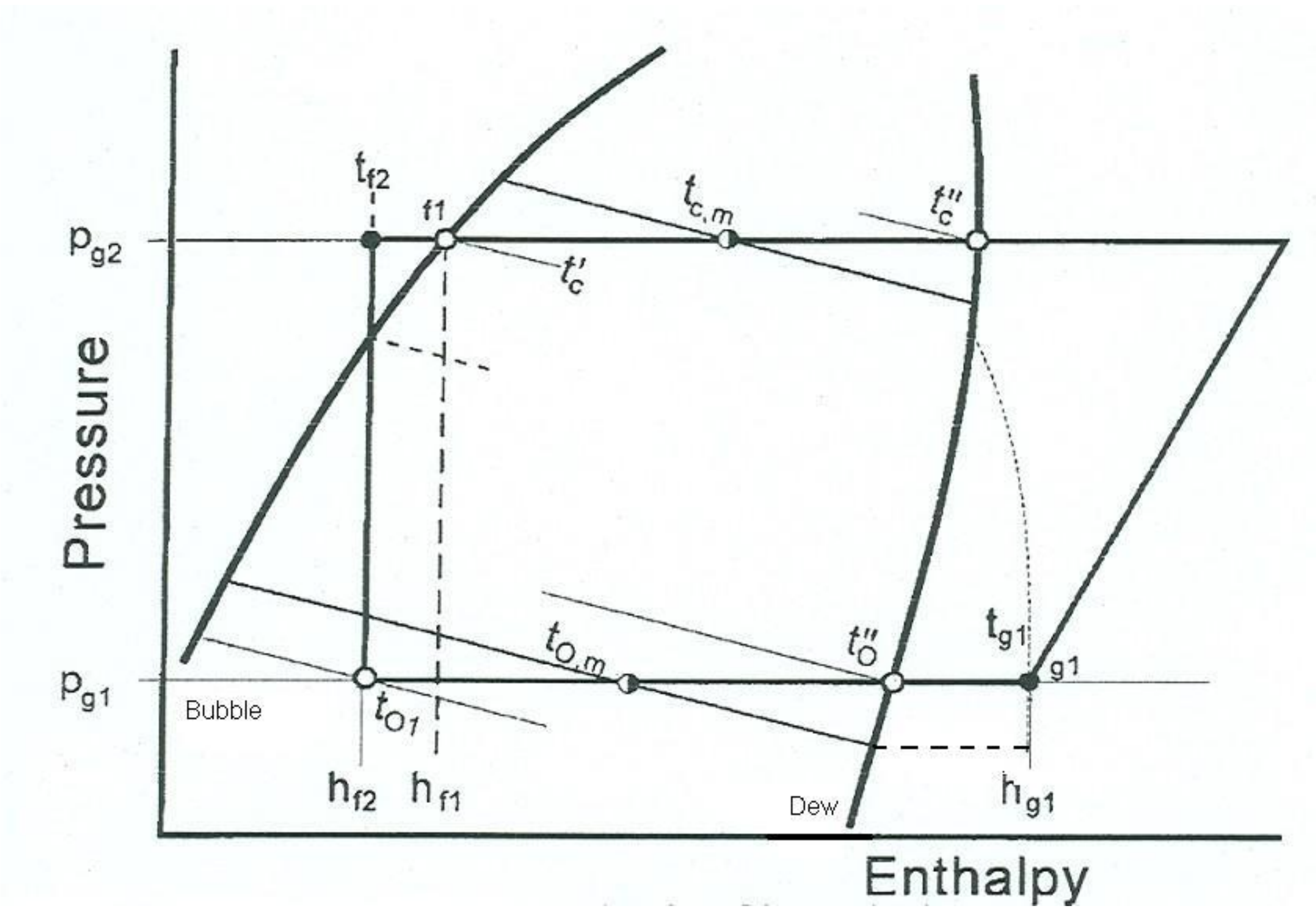

Figure C2: Cycle Process for Zeotropic Refrigerant Mixtures

Figure C2 shows "temperature glide" for zeotropic refrigerant mixtures at the evaporation and condensation processes. Standard reference temperatures are the dew-point temperatures t''_0 at the evaporating pressure p_{g1} and t''_c at the condensing pressure p_{g2}.

The following equations may be used to calculate the mean evaporating temperature, mean condensing temperature, refrigerant superheating, and refrigerant subcooling:

mean evaporating temperature: $t_{0,m} = (t_{01} + t''_o) / 2$ C1

mean condensing temperature: $t_{c,m} = (t'_c + t''_c) / 2$ C2

refrigerant superheating: $\Delta t_{Sg} = t_{g1} - t''_o$ C3

refrigerant subcooling: $\Delta t_{Sf} = t'_c - t_{f2} = t_{f1} - t_{f2}$ C4

Because $t_{01} = t''_0$ and $t'_c = t''_c$ for single-component refrigerants and azeotropic multi-component refrigerants, the cycle process model represents a particular kind of model for zeotropic refrigerant mixtures.

In all reference systems, refrigerating capacity is:

$$Q = \dot{m} (h_{g1} - h_{f2}) \quad \text{C5}$$

and

$$Q_0 = \dot{m}\,(h_{g1} - h_{f1}) \qquad \text{C6}$$

for refrigerating capacity converted to no subcooling.

The reference systems described above allow one to calculate and present performance data for all kinds of refrigerants in a similar way.

ISO 917 requires zero subcooling for the calculation of refrigerating capacity of the compressor. In this case h_{f1} and h_{f2} are equal.

Note: In connection with zeotropic mixtures, different definitions of the expressions superheating and subcooling can be found in technical documentation (Figure C3). The Equations C3 and C4 are equivalent to **A** in Figure C3 and shall be used for the purpose of calculating ratings. For reference only, **B** in Figure C3 with mean temperatures as reference points, uses the following equations:

refrigerant superheating: $\Delta t_{Sg} = t_{g1} - t_{0,m}$ C7

refrigerant subcooling: $\Delta t_{Sf} = t_{c,m} - t_{f2} \neq t_{f1} - t_{f2}$ C8

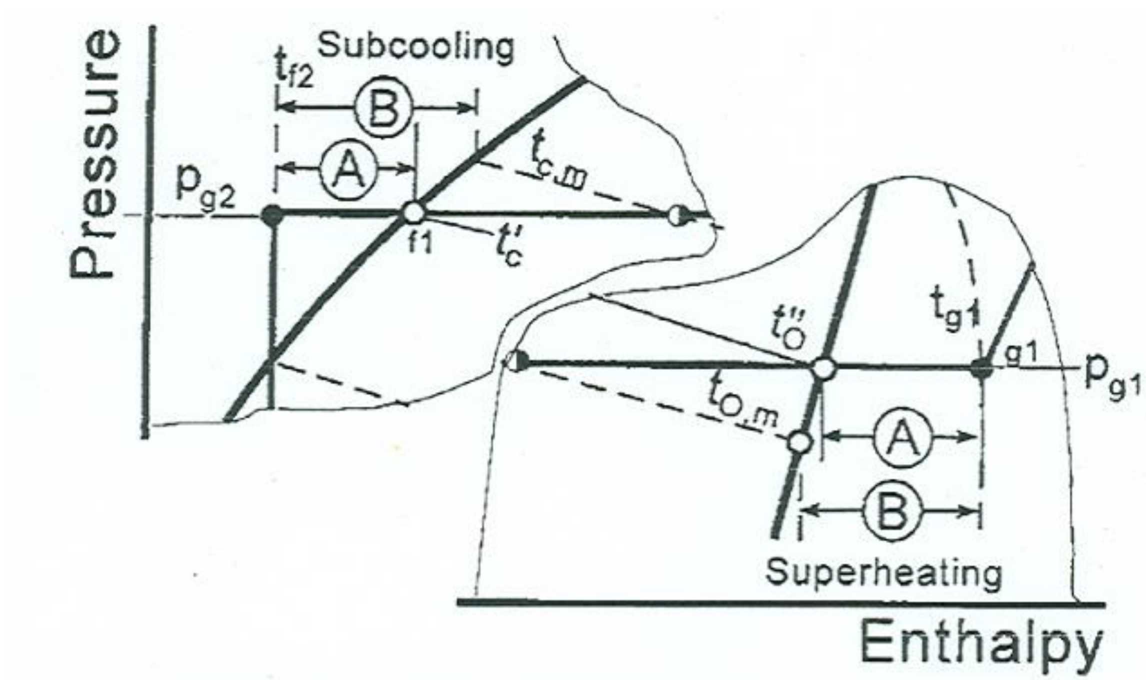

Figure C3: Definitions of Subcooling and Superheating

C2 Symbols and Subscripts

Symbols:

f_1 = Bubble point at condensing process.
g_1 = Point where the refrigerant enters the compression process.
g_2 = Point where the refrigerant leaves the compression process
h_{f1} = Enthalpy of the refrigerant at bubble point of condensing process.
h_{f2} = Enthalpy of the subcooled refrigerant liquid entering the expansion process.
h_{g1} = Enthalpy of the refrigerant gas entering the compression process.
$\dot{m}$ = Refrigerant mass flow rate.
p_{g1} = Compressor suction dew point pressure.
p_{g2} = Compressor discharge dew point pressure.
Q = Refrigerating capacity.
Q_0 = Refrigerating capacity assuming no subcooling.
t_c = Condensing temperature.
t_c' = Bubble point temperature at condensing process.
t_c'' = Dew point temperature at condensing process.
$t_{c,m}$ = Mean condensing temperature.
t_{f1} = Temperature at which the subcooled liquid exits the expansion process
t_{f2} = Temperature at which the subcooled liquid enters the expansion process.
t_{g1} = Temperature of the refrigerant entering the compression process.
t_0 = Evaporating temperature.
t_0'' = Dew point temperature at evaporation process.
t_{01} = Temperature at the outlet of the expansion process and inlet to the evaporation process.
$t_{0,m}$ = Mean evaporating temperature.
Δt_{sf} = Refrigerant subcooling.
Δt_{sg} = Refrigerant superheat.

Subscripts:

$_c$ = Condensing process
$_{c,m}$ = Mean condensing process
$_{f1}$ = Bubble point of condensing process
$_{f2}$ = Point at which the subcooled refrigerant liquid enters the expansion process
$_{g1}$ = Dew point at compressor suction
$_{g2}$ = Dew point at compressor discharge
$_0$ = Evaporating process
$_{01}$ = Outlet of the expansion process and inlet to the evaporation process
$_{0,m}$ = Mean evaporating process
$_{sf}$ = Saturated fluid
$_{sg}$ = Saturated gas